

TITLE OF THE INVENTION

ANTENNA STRUCTURE FOR ELECTRONIC DEVICE WITH WIRELESS  
COMMUNICATION UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application is based upon and claims the  
benefit of priority from the prior Japanese Patent  
Application No. 2002-300910, filed October 15, 2002,  
the entire contents of which are incorporated herein by  
reference.

10                           BACKGROUND OF THE INVENTION

1. Field of the Invention

          The present invention generally relates to  
electronic devices with a wireless communication  
function, and relates in particular to a diversity type  
15 of antenna technology.

2. Description of the Related Art

          Various kinds of electronic devices with  
a wireless communication function which are applied,  
for example, to a wireless LAN (Local Area Network)  
20 have recently been developed. More specifically,  
such electronic devices include portable information  
terminals (or PDAs), personal computers, or other  
digital devices.

          In connection with such electronic devices,  
25 antennas in a so-called diversity antennas are drawing  
attention in an attempt to obtain space diversity  
effects and polarization diversity effects (e.g., refer

to Jpn. Pat. Appln. KOKAI Publication No. 2000-114848).  
Further, an electronic device equipped with a plurality  
of antennas has been developed to comply with a  
wireless communication function in a different wireless  
communication method (e.g., refer to Jpn. Pat. Appln.  
KOKAI Publication No. 2002-73210).

Incidentally, for example, in the wireless LAN  
constructed on the basis of a standard created by  
the IEEE802.11 committee, dual-band electronic devices  
are requested which are applied to both a wireless  
communication function in a 5 GHz frequency band in  
accordance with standard 11a of the committee and a  
wireless communication function in a 2.4 GHz frequency  
band in accordance with standard 11b (or 11g) of the  
committee.

An antenna structure employing the diversity  
antennas in a receiving mode is usually applied to  
such dual-band electronic devices. This is an antenna  
structure with a total of four antennas, that is, two  
antennas including a transmission-receiving antenna  
adaptive to a frequency band of 5 GHz and a receiving  
antenna in the diversity structure, and two antennas  
adaptive to a frequency band of 2.4 GHz.

However, in small-sized electronic devices such  
as notebook-sized personal computers and portable  
information terminals, it is difficult to mount four  
antennas because of severe restrictions in mounting

components.

#### BRIEF SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, there is provided an electronic device  
5 with a diversity type of antenna unit which has two transmission-receiving antennas respectively adaptive to different frequency bands, and one receive-dedicated antenna.

The electronic device comprises: two transmission-  
10 receiving antennas respectively adapted to different frequency bands; a receiving antenna for the frequency bands which forms two diversity antennas together with the transmission-receiving antennas; and a wireless communication unit connected to the transmission-  
15 receiving antennas and the receiving antenna, which performs wireless communication in each of the frequency bands.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated  
20 in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

25 FIG. 1 is a block diagram showing essential parts of an electronic device associated with a first embodiment of the present invention;

FIG. 2 is a block diagram associated with a second embodiment;

FIG. 3 is a block diagram associated with a third embodiment; and

5        FIG. 4 is a view showing an appearance of a personal computer as a specific example of the electronic device associated with the first embodiment.

#### DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will hereinafter be described with reference to the drawings.  
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FIG. 1 is a block diagram showing essential parts of an electronic device with a diversity type of antenna unit associated with a first embodiment.  
(Configuration of the electronic device)

15        An electronic device 1 is, for example, a notebook type of personal computer or portable information terminal (or PDA), and has a built-in wireless communication unit which realizes a wireless communication function in a wireless LAN in two kinds of frequency  
20        bands.

Here, the two kinds of frequency bands mean specifications of the wireless LAN in a 5 GHz frequency band in accordance with, for example, standard IEEE802.11a (this may hereinafter be noted as HF),  
25        and the wireless LAN in a 2.4 GHz frequency band in accordance with, for example, standard IEEE802.11b which is on a relatively low frequency (this may

hereinafter be noted as LF). It should be noted that the specifications of the LF wireless LAN may be based on standard IEEE802.11g, for example.

5 The wireless communication unit broadly has an RF (radio frequency) circuit in a 2.4 GHz band and an RF circuit in a 5 GHz band, and is structured on a wireless LAN circuit module substrate, for example. The RF circuit in a 2.4 GHz band includes an LF transmission unit 10 and an LF receiving unit 11.  
10 The RF circuit in a 5 GHz band includes an HF transmission unit 12 and an HF receiving unit 13.

The RF circuit in a 2.4 GHz band includes a transmission-receiving switch circuit 14 and a diversity (DIV) switch circuit 15. The RF circuit in  
15 a 5 GHz band includes a transmission-receiving switch circuit 16, a diversity (DIV) switch circuit 17, and a high-pass filter (HPF) 18.

On the other hand, the electronic device 1 comprises an antenna unit which has an LF transmission-receiving antenna 20, an HF transmission-receiving  
20 antenna 21, and a receive-dedicated antenna 22 which is a dual-band antenna used in common for LF and HF. This antenna unit has a diversity type of antenna structure adaptive to LF and HF frequency bands, as  
25 will be described later. This is an antenna structure capable of obtaining diversity effects adaptive to each of the frequency bands in a receiving mode.

The LF transmission-receiving antenna 20 is connected to the transmission-receiving switch circuit 14 via a coaxial cable 200. The transmission-receiving switch circuit 14 transfers a transmission signal from the LF transmission unit 10 to the LF transmission-receiving antenna 20 in a transmission mode. Further, the transmission-receiving switch circuit 14 transfers a signal received by the LF transmission-receiving antenna 20 to the LF receiving unit 11 via the DIV switch circuit 15 in a receiving mode.

The HF transmission-receiving antenna 21 is connected to the transmission-receiving switch circuit 16 via a coaxial cable 221. The transmission-receiving switch circuit 16 transfers a transmission signal from the HF transmission unit 12 to the HF transmission-receiving antenna 21 in a transmission mode. Further, the transmission-receiving switch circuit 16 transfers a signal received by the HF transmission-receiving antenna 21 to the HF receiving unit 13 via the DIV switch circuit 17 in a receiving mode.

On the other hand, the receive-dedicated antenna 22 is connected to the DIV switch circuit 15 via a coaxial cable 222. The receive-dedicated antenna 22 is also connected to the HPF 18 via the coaxial cable 222. This HPF 18 is connected to the DIV switch circuit 17.

In a receiving mode, the DIV switch circuit 15

compares received power of the LF transmission-receiving antenna 20 with that of the receive-dedicated antenna 22, so as to switch to an antenna side (20 or 22) indicating a higher level. Further, in a receiving mode, the DIV switch circuit 17 compares received power of the HF transmission-receiving antenna 21 with that of the receive-dedicated antenna 22, so as to switch to an antenna side (21 or 22) indicating a higher level. (Antenna structure)

The present antenna unit has an antenna structure in which the LF transmission-receiving antenna 20 and the HF transmission-receiving antenna 21 are arranged at predetermined distances DL, DH from the receive-dedicated antenna 22, as shown in FIG. 1.

Here, if a wavelength in the 2.4 GHz LF band is  $\lambda_b$ , the LF transmission-receiving antenna 20 is positioned at a distance DL of  $(2n + 1) * \lambda_b / 4$  (however,  $n = 1, 2, 3, \dots$ ) from the receive-dedicated antenna 22.

Furthermore, if a wavelength in the 5 GHz HF band is  $\lambda_a$ , the HF transmission-receiving antenna 21 is positioned at a distance DH of  $(2n + 1) * \lambda_a / 4$  (however,  $n = 1, 2, 3, \dots$ ) from the receive-dedicated antenna 22.

Such an arrangement relation among the three antennas enables an antenna structure adaptive to the LF and HF frequency bands, and capable of obtaining

advantageous diversity effects in a receiving mode.  
(Functional effects of the embodiment)

For example, in a transmission mode of the LF  
wireless LAN, the transmission-receiving switch circuit  
5 14 allows an RF signal output from the LF transmission  
unit 10 to be transmitted as radio waves from the LF  
transmission-receiving antenna 20. Further, in  
a transmission mode of the HF wireless LAN, the  
transmission-receiving switch circuit 16 allows an RF  
10 signal output from the HF transmission unit 12 to be  
transmitted as radio waves from the HF transmission-  
receiving antenna 21.

On the other hand, in a receiving mode of the LF  
wireless LAN, the transmission-receiving switch circuit  
15 14 allows an RF signal received by the LF transmission-  
receiving antenna 20 to be transferred to the DIV  
switch circuit 15. At the same time, the RF signal is  
also received by the receive-dedicated antenna 22 to be  
transferred to the DIV switch circuit 15. The DIV  
20 switch circuit 15 compares received power of the LF  
transmission-receiving antenna 20 with that of the  
receive-dedicated antenna 22, so as to transfer the RF  
signal received by an antenna side indicating a higher  
level to the LF receiving unit 11.

25 Furthermore, in a receiving mode of the HF  
wireless LAN, the transmission-receiving switch  
circuit 16 allows an RF signal received by the HF



transmission-receiving antenna 21 to be transferred to  
the DIV switch circuit 17. At the same time, the RF  
signal is also received by the receive-dedicated  
antenna 22 to be transferred to the DIV switch  
5 circuit 17.

Here, the HPF 18 extracts only the RF signal  
in the 5 GHz band, which is HF, from the RF signal  
received by the receive-dedicated antenna 22 to  
transmit it to the DIV switch circuit 17. The DIV  
10 switch circuit 17 compares received power of the HF  
transmission-receiving antenna 21 with that of the  
receive-dedicated antenna 22, so as to transfer the RF  
signal received by an antenna side indicating a higher  
level to the HF receiving unit 13.

15 As described above, to be brief, the electronic  
device of the present embodiment can realize the  
diversity antenna by the antenna structure with a total  
of three antennas including the two transmission-  
receiving antennas 20, 21 adaptive to the LF and HF  
20 frequency bands, and one receive-dedicated antenna 22  
adaptive to each of the frequency bands and thus used  
in common. In other words, the wireless communication  
function can be achieved which is capable of obtaining  
diversity effects with the dual bands adaptive to the  
25 LF and HF frequency bands.

The diversity antenna usually needs a four-antenna  
structure, but because one antenna member can be

eliminated, so that it is possible to save an antenna mounting space in the electronic device. This is therefore effective especially in small-sized electronic devices such as small notebook-sized  
5 personal computers and portable information terminals with a limited space for mounting components.

In addition, the wireless communication unit of the present embodiment has a configuration in which the HPF 18 separates the RF signal received by the  
10 receive-dedicated antenna 22. Therefore, a complicated RF switch circuit or the like is not particularly needed, and it is thus possible to achieve a dual-band wireless communication function with small receiving losses and simple circuitry.

15 (Mounting configuration of the antenna unit)

A mounting configuration of the antenna unit in the present embodiment will be described below with reference to FIG. 4 on the assumption that the electronic device 1 is a notebook-sized personal  
20 computer 40, for example.

The present personal computer 40 visually comprises a computer main unit 41, and a display device 43 pivotally attached to the computer 41 via hinges 42.

The computer main unit 41 has a circuit board 60  
25 on which the wireless communication unit described above is mounted, in addition to a main circuit board on which a CPU and the like are mounted and a keyboard.

An RF circuit group 61, for example, in a 2.4 GHz band and an RF circuit group (including the HPF 18 and the like) 62, for example, in a 5 GHz band are mounted on the circuit board 60.

5           The display device 43 is constituted of a case which holds a liquid crystal display panel 44. As shown in FIG. 4, the display device 43 has antenna substrates 45, 46, 47 on which the two transmission-receiving antennas 20, 21 and one receive-dedicated  
10       antenna 22 described above are mounted, in an upper part of the case, on a backside of the liquid crystal display panel 44. These antenna substrates 45, 46, 47 are circuit boards whose one side is made of a glass epoxy material, for example. It should be noted that  
15       the antennas 20 to 22 are arranged so as to project to a display surface side of the liquid crystal display panel 44.

          Furthermore, the transmission-receiving antennas 20, 21 are disposed at a distance of, for example, 3 mm  
20       or more from an edge of the liquid crystal display panel 44. Such a configuration enables the case of the display device 43 to keep being thin. Moreover, omnidirectional radiation characteristics can be  
25       obtained without deflection to any of the display surface side or backside of the liquid crystal display panel 44. In addition, the antennas 20 to 22 can be disposed at relatively high positions, so that

it is possible to acquire a transmission-receiving environment with little influence of the surroundings.

Here, the receive-dedicated antenna 22 is disposed in the vicinity of an upper center of the liquid crystal display panel 44 between the transmission-receiving antennas 20, 21, as in the case shown in FIG. 1. In an arrangement relation among the three antennas, the antenna structure is realized which adapts to the LF and HF frequency bands and can obtain advantageous diversity effects in a receiving mode.

More specifically, if a wavelength in the 2.4 GHz LF band is  $\lambda_b$ , the LF transmission-receiving antenna 20 is positioned at a distance of  $(2n + 1) * \lambda_b / 4$  (however,  $n = 1, 2, 3, \dots$ ) from the receive-dedicated antenna 22. Here, in the case of the notebook-sized personal computer 40, the two antennas should desirably be separated from each other as far as possible, more concretely, at a distance resulting in, for example, " $n = 2$ " so as to reduce interference between the antennas. To be concrete, the antennas 20 and 22 are arranged with a distance of about 160 mm as shown in FIG. 4, due to the wavelength  $\lambda_b$  in the LF band.

On the other hand, if a wavelength in the 5 GHz HF band is  $\lambda_a$ , the HF transmission-receiving antenna 21 is positioned at a distance of  $(2n + 1) * \lambda_a / 4$  (however,  $n = 1, 2, 3, \dots$ ) from the receive-dedicated antenna 22. The antennas 21 and 22 are arranged about 105 mm

away from each other, concretely, at a distance resulting in, for example, "n = 3" as shown in FIG. 4, due to the wavelength  $\lambda_a$  in the HF band.

Furthermore, the three antennas 20, 21, 22 are  
5 connected to the circuit board 60 of the wireless communication unit built in the computer main unit 41 via coaxial cables 50, 51, 52, respectively. This wireless communication unit comprises the same circuitry as that in FIG. 1.

10 With such an antenna mounting configuration, the antenna structure advantageous in the diversity effects can be realized in the case of the display device 43 especially using an upper portion space thereof, on the assumption that the electronic device 1 is, for  
15 example, the notebook type of personal computer 40. Concretely, it is possible to reduce the interference between the antennas or spurious effects. In addition, owing to the configuration in which the antennas project to the display surface side of the liquid  
20 crystal display panel 44, thickness of the case of the display device 43 can be retained, and well-balanced radiation characteristics can be obtained both on the display surface side and backside.

(Second embodiment)

25 FIG. 2 is a diagram showing a second embodiment.

In the electronic device 1 of the present embodiment, the receive-dedicated antenna 22 is

connected to band pass filters (BPF) 180a, 180b in the wireless communication unit via the coaxial cable 222.

The BPF 180a is connected to the DIV switch circuit 15 to extract a frequency signal adaptive to the LF band from a radio frequency signal received by the receive-dedicated antenna 22. On the other hand, the BPF 180b is connected to the DIV switch circuit 17 to extract a frequency signal adaptive to the HF band from a radio frequency signal received by the receive-dedicated antenna 22.

Such a configuration can also realize the diversity type of antenna structure adaptive to the LF and HF frequency bands, similarly to the primary embodiment. It should be noted that the configuration of other parts is the same as that in the primary embodiment shown in FIG. 1 and will not be described. (Third embodiment)

FIG. 3 is a diagram showing a third embodiment.

In the electronic device 1 of the present embodiment, the receive-dedicated antenna 22 is directly connected to the DIV switch circuit 17 via the coaxial cable 222. The receive-dedicated antenna 22 is also connected to a low pass filter (LPF) 181 via the coaxial cable 222. The LPF 181 is connected to the DIV switch circuit 15 to extract a frequency signal adaptive to the LF band from a radio frequency signal received by the receive-dedicated antenna 22.

Such a configuration can also realize the diversity type of antenna structure adaptive to the LF and HF frequency bands, similarly to the primary embodiment. It should be noted that the configuration of other parts is the same as that in the primary embodiment shown in FIG. 1 and will not be described.

In addition, the configuration of the wireless communication unit is not limited to the configurations in the primary embodiment and modifications, and the wireless communication unit may have other configurations. More specifically, such a configuration may be possible wherein the receive-dedicated antenna 22 is connected to the DIV switch circuit 15 via the LPF 181, and also connected to the DIV switch circuit 17 via the HPF 18. Further, such a configuration may also be possible wherein the RF circuit group and LF circuit group are connected to the receive-dedicated antenna 22 via a switch circuit. In this case, the DIV switch circuits 15, 17 may be configured to have a filter circuit for adaptation to each of the frequency bands.

As described above in detail, the embodiments can reduce the space for mounting antennas, and thus can provide a small-sized and high-performance electronic device. More concretely, more antenna members can be reduced than in the conventional four-antennas structure, which is thus effective especially in small-sized electronic devices with a limited space for

mounting components.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to  
5 the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general invention concept as defined by the appended claims and their equivalents.